Attorney Docket: 2802/101

Methods and Devices for Building Construction

Cross Reference to Related Applications

This application claims priority from a Finnish provisional patent application with application number FI 20030573 filed April 15, 2003, and a Finnish provisional patent application with application number FI 20040420 filed March 18, 2004, both of which are incorporated in their entirety herein by reference.

Technical Field

The present invention relates to construction systems that reduce the growth of mold, mildew and other fungi; aid in the removal of moisture; and involve modular construction systems.

Background Art

Numerous problems continue to persist in the construction of buildings. In attempts to achieve building structures that are warmer, more durable, and better sealed than before, the significance of ventilation and air changing has often been overlooked. Increasingly, mold problems and soft, decomposing chipboard, plasterboard, and wall framing are being found in bath and washrooms in buildings, the cause of which is the failure of damp proofing and the entry of moisture into the structures, along with insufficient ventilation of the structures.

As well, the time and effort required to construct a new building, or to modify an existing one, continues to be substantial. Beyond creating the supporting framework, the building structure often includes the addition of utility systems, such as plumbing, electricity, and air circulation. Installation of one or more of these utility systems further slows the time of completion, and increases the effort required to construct buildings.

Summary of the Invention

In one embodiment of the invention, a room-bounding structure includes a rigid sheet, which is substantially impermeable to moisture; and a spacer protrusion extending from a first surface of the rigid sheet, the protrusion being rigidly formed from the rigid sheet. Contact between the spacer protrusion and a rigid surface sheet forms an air channel on the first surface side of the rigid sheet for ventilating air through the structure. More than one spacer protrusion may be distributed over an area of the rigid sheet.

The room-bounding structure may additionally include a distribution duct with one or more openings for introducing ventilating air to the structure. The distribution duct may introduce ventilating air from a dry interior space of a building, and may include a plurality of openings with progressively changing sizes, or openings ordered to be progressively closer to one another, to minimize dead space in the air channel. The structure may further include a collection duct with at least one opening for removing ventilating air from the structure, wherein the distribution duct is located at an edge of the structure and the collection duct is located at an edge of the structure opposite from the distribution duct. In the instance where the structure is part of a, or an entire, wall, the distribution duct may be arranged in a lower part of the wall structure and the collector duct is arranged in an upper part of the wall structure, or visa versa.

The room-bounding structure may also include a collector duct with at least one opening for removing ventilating air from the structure. The collector duct may remove ventilating air from the structure to a mechanical air extractor, such a mechanical air extractor may also ventilate a bathroom. The collection duct may include a plurality of openings with progressively changing sizes configured to minimize dead space in the air channel, or alternatively the openings may be ordered to be progressively closer to one another to achieve the same effect.

The spacer protrusion of the embodiment of the invention may be in contact with mineral board, or a coated steel plate. The room-bounding structure may include a wall and a floor, a ceiling, or both.

As well, the room-bounding structure may include one or more spacer protrusions on a second surface of the rigid sheet such that contact between the spacer protrusion and another rigid surface sheet forms an air channel on the second surface side of the rigid sheet.

The spacer protrusion on the second surface may be rigidly formed from the rigid sheet, or may be an edge flange bent into the edge of the another rigid surface sheet. As well, the spacer protrusion on the second surface may be in contact with mineral board, a sheet that is at least part organic building board, or a coated steel plate.

The room-bounding structure may also include an attachment flange connected to an edge of the rigid sheet, and configured to attach to an adjacent structure to form a rigid unified structure. The structure may also include a sensor capable of providing a measure of the moisture content of the ventilating air.

In another embodiment of the invention, a modular room for a building includes a prefabricated room including a ceiling; a floor; and walls supporting the roof and floor, wherein the room is prefabricated remotely from a location of the building that includes the room, and the room is capable of being modularly connected to the building at the location of the building; and a utility connection capable of connecting a utility system of the room to a corresponding utility system of the building. The utility connection may be for a plumbing system, an electrical system, or a HVAC system. The utility connection may be linked directly to the utility system of an adjacent room. Such a modular room may also include a room-bounding structure, as described for other embodiments of the invention. The modular room may be sealed upon fabrication and unsealed only after the room is modularly connected to the building.

In another embodiment of the invention, a structural system for forming at least part of a room-bounding structure includes a casted structure; and a perforated conduit for flowing a gas therethrough, the gas entering the perforated conduit through an inlet and exiting the perforated conduit through an outlet, the inlet and outlet being positioned outside the casted structure. At least a portion of the perforated conduit is embedded in the casted structure. The casted structure may include casted concrete, and the perforated conduit may include a plastic pipe. The portion of the perforated conduit embedded in the casted structure may include an exterior wall of the perforated conduit exposed outside the casted structure, or the portion of the perforated conduit embedded in the casted structure may be entirely embedded in the casted structure.

The perforated conduit may have a higher number density of perforations per external surface area of conduit surface in at least one section of the conduit embedded in the casted

structure than in another section of the conduit embedded in the casted structure, the at least one section of conduit configured to be more exposed to water than the another the another section of the conduit. Alternatively, the perforated conduit may have at least one larger perforation in at least one section of the conduit embedded in the casted structure than in another section of the conduit embedded in the casted structure, the at least one section of conduit configured to be more exposed to water than the another the another section of the conduit.

The outlet of the structural system may be connected to a ventilation duct, or to a fan. As well, the inlet may be connected to a fan. The perforated conduit of the structural system embedded in at least one section of the casted structure may be configured to be proximate to a water source. Also, a sensor may be located after the outlet for providing a measure of moisture content of the gas flowing through the outlet.

Brief Description of the Drawings

The foregoing features of the invention will be more readily understood by reference to the following detailed description, taken with reference to the accompanying drawings, in which:

Figure 1 shows one wall structure according to an embodiment of the invention,

Figure 2 shows two wall structures positioned adjacent to one another, in accord with an embodiment of the invention,

Figure 3 shows a cross-sectional view of a wall structure including wood paneling, in accord with an embodiment of the invention,

Figure 4 shows an embodiment of the invention in the form of a wall structure including insulation,

Figure 5 shows a cross-sectional view of a wall structure in accord with an embodiment of the invention,

Figure 6 shows a cutaway view of an implementation of a ventilating room-bounding structure in the floor and walls of a bathroom, according to an embodiment of the invention,

Figures 7A, 7B, and 7C show a top view, a perspective view, and a side view, respectively, of two modular rooms according to an embodiment of the invention,

Figure 8 shows an embodiment of the invention, where modular units with ventilating wall structures are located one above another,

Figure 9 shows schematically and in partial cross-section the implementation of a room-bounding structure according to an embodiment of the invention,

Figure 10 shows a side view of an embodiment of the invention utilizing a casted structural system for ventilating part of a room-bounding structure,

Figure 11 shows a diagrammatic bottom view of an embodiment of the invention showing a perforated pipe configured to be selectively embedded in a casted structure near sources of water or moisture, and

Figure 12 shows a diagrammatic perspective view of an embodiment of the invention utilizing a perforated pipe selectively embedded in the casted structures forming the floor and walls of a room.

Detailed Description of Specific Embodiments

Figure 1 depicts one embodiment of the invention as a bathroom wall structure, in which, for example, a relatively rigid sheet **1** is formed from a metal sheet, by making spacer protrusions **3**, i.e. protrusions shaped as a truncated cone, on its first surface **2**. In addition, another pair of opposite sides of the sheet are bent at 90° to form support structures, i.e. edge flanges **7**, the outer edges of which are bent at a further 90° towards each other to form support flanges **9** parallel to the sheet **1**.

Other types of materials may be used for the rigid sheet **1** besides metal (e.g., plastic or composite). The rigid sheet **1** is typically, but not necessarily, substantially impermeable to moisture. As well, the spacer protrusions **3** may take any convenient shape, and is not limited to the form of a truncated cone. In a preferred embodiment, the spacer protrusions are created by shaping the rigid sheet to form such protrusions. Spacer protrusions may also be in the form of independent structures formed in the shape of the protrusions and attached to the rigid sheet.

A rigid surface sheet **4** may be fitted to the structure, to be supported against the straight flat surfaces **10** of the truncated cones **3**, in such a way that a network of air channels **5**, in which air can flow and ventilate the wall structure, is formed in the gaps between the spacer protrusions **3**. In a preferred embodiment, the rigid surface sheet is water resistant,

and includes the use of mineral board. Water resistant sheets for use with embodiments of the invention may include other materials known to those skilled in the art, such as plastic-coated or film-laminated steel plate that impart a water resistant nature to the plate.

The support flanges **9** are in turn supported and attached to the surface sheet **8** of the second side of the structure, which can be selected according to the environmental conditions. If the second side of the structure too is bounded by a wet space, a water-resistant sheet, e.g., mineral board, should also be used. But if the space in question is absolutely dry, any building board at all can be used as the surface sheet **8**. Thus, the second-side surface sheet **8** and the sheet **1** form between them a second network of air channels **11**, which is ventilated entirely separately from the channel network **5** of the first side.

According to another embodiment of the invention shown in Figure 2, adjacent wall structures, configured for example as depicted in Figure 1, may be attached to each other by their support structures, i.e. the edge flanges **7**, to form a rigid extensive totality. Such an embodiment allows an air channel network **5** to extend in a relatively unified form over the entire area over which the relevant structures extend in the bathroom, i.e. preferably over the entire surface area of all the bathroom walls. It is also possible to use openings **12** in the edge pieces **7** of each wall structure to form a connected air circulation path on the sides of the wall structures opposite the extension of the spacer protrusions, which is separate from the air channel network **5**.

The bathroom wall structure depicted in Figures 1 and 2 may be used in other wall applications in a building as well. For example, if moisture is of minimal concern, a non-water resistant sheet may be used for the rigid surface sheet. The wall structure may be particularly useful, however, for rooms containing moist environments. For example, such wall structures may be used in a sauna. As depicted in the embodiment of the invention shown in Figure 3, a sauna using the wall structure may include an additional layer **32**, typically wood paneling, is placed over and spaced from a water resistant sheet **4** in order to permit flow from within the through the resulting space **31** between the water resistant sheet **4** and the additional layer **32**. Non-limiting examples of materials used for the water resistant sheet **4** include mineral board, or a polyurethane coated aluminum panel. The aluminum panel may be used to reflect heat back to the sauna.

Figure 4 shows an embodiment of the invention, which is similar to the wall structure of Figure 1, i.e. it has a mineral board **4** supporting a metal sheet **1**, between which is an air-channel network **5**. The edges of the metal sheet are bent to form edge flanges **7** and support flanges **9**, to which the second mineral board **8** is attached. In addition, in this embodiment, the space partially enclosed by the metal sheet **1** and its bends **7** and **9** contains a suitable thermal or acoustic insulation **13**. Particularly in this embodiment, but also in the other embodiments, the sheet **1** can be shaped such that the spacer protrusions are made on both surfaces of the sheet **1**. Air-channel networks, which ventilate the structure, are then formed on both sides of the sheet **1**. Of course, the air-channel network can be implemented using a thinner insulation **13**, thus leaving an air gap between the insulation and the sheet **1**.

Figure 5 shows the basic structure of an embodiment of the invention, i.e. the metal sheet **1**, in which there are truncated cone spacer protrusions **3**. A mineral board **4** is set against the flat surfaces of the protrusions, thus forming a network of air channels **5** between the sheet **1** and the mineral board **4**.

Figures 6 and 9 show, schematically and in partial cross-section, an embodiment of the invention that utilizes floor and wall ventilation in a bathroom. At the bottom of an end wall of the bathroom, a distribution duct **13** extends over the entire length of the end wall, in which the flow of dry air from a source **14** is inserted into the floor **16**. The flow openings **15** in the distribution duct **13** increase in size in the downstream direction of flow, so that roughly the same amount of air flows from each flow opening into the air-duct network **16** in the floor of the bathroom. In a corresponding manner, there may be flow openings in the distribution duct that lead part of the air up the end wall on top of the duct and through a wall **16** to the bathroom ceiling.

From the floor **16**, the air flow is distributed evenly, in the manner shown by the arrows, to both of the side walls **17** of the bathroom and to the second end wall **18**. A collector duct **19** is arranged along the upper edges of these walls, in which, by adjusting the size of the flow openings, the force of the air flow is made as even as possible over the entire area of the air-channel networks. The collector ducts **19** are connected to each other and led to an extractor fan **20**, to the suction side of which the suction pipe **22** of the bathroom exhaust air vent **21** is also connected.

In a manner known by those skilled in the art, the cross-sections of the flow openings and the flow ducts can be configured to achieve flows of air that are distributed as evenly as possible to the various parts of the various structures of the bathroom, or to other living spaces. Such a configuration minimizes the dead space in the air channel network, i.e. areas where little or no air flows. In addition, air flow may also be controlled by varying the number of openings in a duct per unit length of duct. For example, in a distribution duct, the number of openings per unit length of duct may increase along the flow direction to more evenly distribute air over the entire length of the distribution duct.

As is readily apparent to those skilled in the art, the ventilating structures described may also be utilized with the ceiling of a room. As well, a distribution duct and collection duct may be located at other locations, and configured in other manners, beyond what is described by embodiments of the invention herein.

In another embodiment of the invention, a structural system for forming part of a room-bounding structure is also utilized to remove moisture. The system includes a casted structure (e.g., a casted concrete structure) and a perforated conduit (e.g., a plastic pipe) embedded in the casted structure. The perforated conduit has one or more perforations allowing moisture, or other gaseous species, to penetrate the outer wall of the conduit. Gas (e.g., air) is flowed through the conduit to facilitate the removal of moisture from the casted structure. The system may be utilized in any room-bounding structure including a floor, ceiling, wall, intermediate floor, or any combination of such structures.

As depicted in Figure 10, an embodiment of the invention includes a solid cast concrete structure **110**, for example, a floor slab. During the casting, perforated plastic pipes **120**, **125** are embedded in the slab. One of the plastic pipes **120** is entirely inside the concrete; in such a way that only its ends **130**, **140** are outside the concrete. The inlets **130, 135** of the pipes **120**, **125** may draw gas from any source. Typically, for example, air is drawn from an exterior source or from a dry source within a building. Air can flow freely in the pipe **120** and moisture is transported into the air from the concrete **110** through the holes in the pipe **120**.

The lower pipe **125** is also installed during casting, but in a center section **155** the pipe **125** is exposed at the level of the lower surface of the shuttering, so that the plastic pipe **125** is half exposed on the under surface of the cast piece **110**, allowing the airspace **150**

under the casting to be ventilated. Thus moisture in the airspace **150** may be removed by the transport of moisture in the space **150** to the interior of the pipe **125,** as well as moisture from within the concrete structure **110,** and exiting the outlet **145**.

Various changes to the elements shown in Figure 10 may be accommodated within the scope of embodiments of the invention. For example the cast structure may be made of any type of concrete, or may be formed from some other type of material (e.g., plaster). As well, the plastic pipe may be substituted with any type of conduit capable of transporting a gas, the conduit being perforated to allow moisture to be transferred into the conduit through the perforations. The perforations may be openings or openings covered by a material permeable to moisture. The conduit may also be made of other materials besides plastic, such as metal. Finally the conduit and casted structure utilized in embodiments of the invention may be a single entity (e.g., a single long pipe, or a single casted structure) or may be modular in nature (e.g., the pipe is made up of sections of piping or the structure may be a composite of casted structures that are assembled). As well, conduits and casted structure need not have any particular size or shape. For example, a conduit may have several branch points.

Figure 11 shows an under view of an embodiment of the invention using a casted structural system in a bathroom environment. A perforated plastic pipe **220** according to the invention is embedded in the cast floor **210** of the bathroom. The plastic pipe **220** enters from one corner of the floor **210** and follows the edge of the floor close to the wall, i.e. where moisture damage can generally appear. At the next corner, the plastic pipe **220** runs quite closely around a toilet drainpipe **260** then runs to the another corner. Close to this third corner is the floor drain **270** of the shower, which the pipe runs around completely (thus increasing the density of perforating conduit near the potential water source), before running towards the fourth corner, close to which is the drain connection **280** of the washbasin. After running around this drainpipe **280**, the plastic pipe **220** runs across the center of the floor **210**, to exit from the edge opposite to that from which it entered. Thus the perforated plastic pipe **220** runs around all the most critical areas of the bathroom floor **210**, where moisture damage can generally occur. Thus the configuration of the pipe **220** and casted structure **210** facilitates the evaporation of moisture from small and especially random moisture leaks,

while damage from major moisture leaks may be mitigated and repaired before more significant damage is able to occur.

In another related embodiment of the invention, the number density of perforations in a conduit may change along the length of the conduit according to particular ventilation or drying requirements. For example, as shown in Figure 11, piping **220** running close to the drains **260, 270, 280** may have a higher number density of perforation in the sections close to the drains **260, 270, 280** relative to other sections of the pipe **220** (e.g. at a non-draining section **250**) to facilitate moisture transport at areas where moisture is potentially more prevalent. Alternatively, or in conjunction, a conduit may utilize different sized perforations to tailor ventilation and drying requirements. For example, piping **220** running close to the drains **260, 270, 280** may have larger sized perforations near the drains **260, 270, 280** than in sections remote from potential water sources **250** to facilitate moisture transport.

The embodiment of the invention depicted in Figure 12 utilizes a structural system for removing moisture in a more extensive manner. A perforated pipe **320** can initially enter, for instance, from a suitable dry interior space **390**, which is typically a source of dry air. First, the pipe runs around the cast floor **300**, then the lower edge **310** of the walls and finally the upper edge **330** of the walls, before it exits from the room.

The exit can be led straight to a duct **350** with natural draught such that a separate source of creating air flow is not required. Alternatively, mechanical aids in ventilation (e.g., a fan placed anywhere upstream, downstream, or along the perforated conduit) may be utilized to drive the flow of air. A heater may also be installed upstream from the perforated conduit, or in the conduit before reaching an area where moisture is to be removed, to heat the gas utilized to transport moisture away (effectively increasing the moisture carrying capacity of the gas). Measurement devices **340** may also be used in connection after the exit of the perforated conduit, or at any location along the perforated pipe **320**, by which means the properties of the exhausting air, such as humidity or temperature, can be monitored at suitable intervals or essentially continuously. Thus, even small events deviating from normal moisture conditions may be monitored. Because changes in moisture content are typically very slow to change in thick concrete structures, only small changes in monitoring frequency are typically necessary in adjusting the monitoring of moisture content. Similarly, it will usually be enough, for example, to use a suitable fan to increase the airflow circulating in the

pipe, in order to remove excess moisture. Such changes in monitoring or fan speed or heating output of a heater may be automatically controlled through the use of a control system, as known to those skilled in the art.

Rooms made with a ventilating structure, as discussed in any of the previous embodiments, may be constructed at the site where the ventilating structure is utilized. Alternatively, the room with the ventilating structure may be prefabricated remotely, i.e. the room is assembled away from the location where a building eventually includes the room. Such pre-fabricated rooms may be constructed in a modular manner, i.e. the room may be modularly connected to a building being constructed or a pre-existing building. Modularity of the room may accommodate rooms being installed adjacent to one another as shown in Figures 7A – 7C, or stacked on top of one another as shown in Figure 8. In a preferred embodiment of this modular construction system utilizing multiple modular rooms, each room may be sealed after being pre-fabricated and only unsealed after the room has been modularly connected and just prior to completion of the building.

In a preferred embodiment of the invention as shown in Figures 7A, 7B, and 7C, a room **70** may be pre-fabricated with fixtures (including plumbing fixtures **71**, electrical fixtures, HVAC components **72**, towel racks, etc.), wall coverings **73**, floor coverings **74**, and other amenities. Such a room may include one or more utility connections **75** to allow the room to be easily integrated with the utility system of the building with which the room is connected. Utility systems may include plumbing, electrical, HVAC, and other utilities implemented with buildings. The utility connections allow the prefabricated room to share the corresponding utility system of the building. For example, a plumbing connection to a prefabricated bathroom may include connections for hot water, cold water, and an outlet line to connect to a sewage line of the building. In another example, the prefabricated room may have connections for a distribution duct a collection duct if the room is configured to utilize the ventilation structures described herein.

In another preferred embodiment of the invention, the modular room is designed such that the utility systems of one module may be connected to the utility system of an adjacent room, instead of each room being independently connected to the master utility system of the building. For example, as depicted by Figures 7A and 7C, the utility connection **76** from one room **77** may be situated to connect with the utility connection **75** of the next room **70**.

Insulation and/or sealant may be injected into the spaces between the rooms **70**, **77** after the rooms **70**, **77** have been connected.

It will be appreciated that such modular utility systems may be used with rooms that do not use the ventilating structures described earlier for inhibiting fungus growth by ventilating the interior of the walls, floors and/or ceilings.

In the above, the invention is described in detail with the aid of the accompanying drawings, different embodiments of the invention being possible within the scope of the inventive idea defined by the claims.